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# JOURNAL

OF THE

## ARNOLD ARBORETUM

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VOLUME XIV.

OCTOBER, 1933

NUMBER 4

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### NOTES ON THE DISTRIBUTION OF WHITE SPRUCE AND BANKSIAN PINE IN NORTHWESTERN CANADA

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*With plates 72 and 73*

THE WHITE SPRUCE, *Picea glauca* Voss (*P. canadensis* of most American authors) is the predominating forest tree throughout the central part of the Mackenzie basin, where its dark green spire-like tops give primary character to nearly every landscape. A traveler descending the Athabaska or Peace River gets the impression that the country is mantled with a heavy spruce forest, but this proves to be an illusion if short inland excursions are made, even if not more than a hundred yards from the river. A considerable part of the timber is found to be on the immediate banks of the rivers, while large areas in the flood plains through which the streams flow are covered with marsh lands separated by low natural levees which hold other narrow bands of timber. This lowland spruce forest is a nearly pure stand of tall, straight-boled trees, with a relatively thick undergrowth of Gray Willow, *Salix Bebbiana*, Mooseberry, *Viburnum pauciflorum*, Red-osier Dogwood, *Cornus stolonifera*, and a wild Rose, *Rosa acicularis*. There is a mat of woodland mosses on the ground in the older of these forests, but it is everywhere thin and in places almost non-existent. A prominent herbaceous species is *Equisetum pratense*, which often makes a continuous greensward on the forest floor. The lowland Spruce is common in suitable situations throughout the central part of the Mackenzie basin and far northward along the main streams. As would be expected it is but scantily developed eastward in the pre-Cambrian country where the thinness of the soils and the absence of large streams has precluded the formation of extensive alluvial deposits.

A spruce timber which is closely related floristically to that of the



lowlands is found on the gently rolling surfaces of the upland country south and west of the Athabaska-Great Slave Lake region where it is interspersed with wide areas of Banksian Pine, *Pinus Banksiana* Lamb. It also occurs, although in a modified form, on the lower slopes of the northern Rocky Mountains in the upper Peace and Liard River basins. Where not disturbed for long periods this forest is a nearly pure stand of the Spruce in the more northern sections, while it is accompanied by *Abies* farther south, *A. lasiocarpa* in the mountains and *A. balsamea* in the southern and southeastern sections. Toward the mountains Banksian Pine is replaced by the Lodge-pole Pine, *P. contorta* var. *latifolia*. Various forms of White Birch, *Betula papyrifera* and var. *occidentalis*, and *B. neoalaskana*, are of frequent though not dominant occurrence. The ground cover is usually a mat of woodland mosses with a very sparse herbaceous growth; and the shrub cover is also thin, consisting chiefly of *Viburnum pauciflorum*, *Alnus crispa*, *Salix Bebbiana*, *Shepherdia canadensis*, and *Rosa acicularis*. The whole differs from that of the lowlands mainly in having a thicker moss cover, relatively lighter shrub growth, and but few herbs. In the mountains the shrubs are more numerous in species and individuals, with the addition of *Acer glabrum* var. *Douglasii* and *Oplopanax horridum*.

The highest and oldest land surfaces on the uplands are on the tops of the erosion plateaus which make the heights of land between the larger streams. The Caribou and Birch Mountains, and the Buffalo Head Hills are typical of these. Their forests have not been extensively investigated, but they seem to be characterized by Cordilleran elements. In the Lesser Slave Lake region they contain the Lodge-pole Pine and the Subalpine Fir, *Abies lasiocarpa*, while at the eastern edge of the Caribou Mountains the former has been found.

Still another type of spruce forest occurs in isolated localities in the central part of the Mackenzie basin as well as in the northern Saskatchewan River drainage of central Alberta. About 20 miles west of the upper Slave River, near the southeastern end of Lane Lake, is a highly morainic country composed largely of sand. On the tops of the highest hills there are open park-like woods in which the individual spruce trees grow with their lower branches on the ground, and in which there is very little shrub growth. The ground cover is principally of lichens, *Cetraria nivalis*, *C. islandica*, *Cladonia alpestris*, etc., and some mat-forming heaths, *Arctostaphylos Uva-ursi*, and *Vaccinium Vitis-Idaea* var. *minus*. Farther westward, near Moose (Eight) Lake, other sandy hills have a similar vegetation. Dr. E. H. Moss has described an iso-



lated stand of Spruce in central Alberta near Edmonton<sup>1</sup> which occupies a similar habitat and seems both floristically and structurally similar to those farther north. It should be noted that these open stands of Spruce occur as "islands" in the ordinary mossy spruce woods described above, or in the dry pine woods. On the high morainic hills, in fact, the Pines occupy the lower slopes while the park-like Spruce is confined to the tops.

Characteristic features of the northwest shores of Lake Athabaska are sand plains and ancient beaches which are many feet above the present level of the lake and form gentle slopes away from the rocky hills. The hills have a scraggly and stunted growth chiefly of scattered Jack Pines, while the plains have an open park-like timber of the same species mixed with Black Spruce, *Picea mariana*, and White Birch.<sup>2</sup> The ground cover in the latter woods is of lichens, *Cladonia alpestris*, *Cetraria nivalis*, etc., and a few mats of *Arctostaphylos Uva-ursi*, *Vaccinium Vitis-Idaea* var. *minus*, and Crowberry, *Empetrum nigrum*. A few taller shrubs are present, the most common being the Blueberry, *Vaccinium canadense*. A further examination of the inland country reveals that the White Spruce may occur in some abundance, but always on local flood plains where small quantities of alluvial silts have been sorted and deposited much as they are along the main rivers. Otherwise it is rather occasional in rock crevices and small soil accumulations in exposed situations. The upland pine woods west of the Slave River grow on sandy soils, and in their younger stages, as will be noted below, closely resemble those just described.

If the observations are continued farther northeastward in the pre-Cambrian country to the eastern part of Great Slave Lake it is noted at once that the Pine has nearly disappeared from the forests, its place being taken almost entirely by the White Spruce. Rocky hills have stunted Spruces with gnarled and twisted trunks, and the sand plains such as are found at the eastern end of the lake have an open spruce wood which has the general aspect of the pine woods farther south.<sup>3</sup> The park-like timber is nearly identical with that of the high morainic hills referred to above.

<sup>1</sup>MOSS, E. H. The Vegetation of Alberta, iv. The Poplar Association and Related Vegetation of Central Alberta. (Jour. Ecol. xx. 412-3. 1932.)

<sup>2</sup>RAUP, H. M. A Survey of the Vegetation of Shelter Point, Athabaska Lake. (Univ. of Pittsburgh Bull. xxv. Oct. 25, 1928.)

<sup>3</sup>RAUP, H. M. The Vegetation of the Fort Reliance Sand Plain. (Annals of the Carnegie Mus. xx. 9-38. 1930.)



To these facts must be added some recent findings on the north shore of Lake Athabaska. About 25 miles northeast of Chipewyan, Sand Point juts out into the lake to a distance of about 2 miles. It is composed entirely of sand, at least at the surface, and has its greatest elevations about a mile from its base. The eastern side of the point has been greatly modified by wind and wave action so that back of a long sand beach there is a steep bank of sliding sand in places about 50 feet high. The tops and upper western slopes of the sandy ridges are more stable and have an open spruce timber similar to that on Great Slave Lake. Other sandy ridges and plains nearer the base of the point are given over to the Pine.

To recapitulate, there are three types of white spruce forests in the central part of the Mackenzie basin. One is of recent development on the flood plains of streams where all the processes in its formation upon newly exposed alluvial deposits may be seen. It is characterized by a rather thin moss cover on the ground, and by a relatively dense undergrowth. A second is widely distributed on the lighter and better drained soils of the uplands, especially where it has not been much disturbed by fire or other agency. It has a much thicker moss mat (4-5 inches) than that of the flood plains, and a rather sparse undergrowth. In the southern sections and in the mountains the Firs are associated with both of these types. The third type has an open, park-like stand of trees in which there is very little undergrowth and no mat of mosses on the ground. The place of the latter is taken by a lichen and heath mat. This type has a scattered distribution in the southwestern portions of the region where it is confined to the tops of high sandy ridges or exposed sandy promontories like Sand Point on Lake Athabaska. On Great Slave Lake, however, it is much more common, covering large areas of sand plain and rocky upland. It is in the form of the last type, with minor modifications, that the Spruce reaches its extreme limit in the arctic tundra.<sup>1</sup>

Random notes made by travelers northeast and east of the Athabaska Lake country suggest a similar arrangement of forest types. J. B. Tyrrell described spruce woods along the Dubaut and Kazan Rivers which must be like those seen on Great Slave Lake.<sup>1</sup> Also, judging from his descriptions the northern limits of the Jack Pine on

<sup>1</sup>TYRRELL, J. B. Report on the Doobaunt, Kazan and Fergusin Rivers and the North-west Coast of Hudson Bay. (Canad. Geol. Surv. Ann. Rept. ix. 163F and 214F. 1898.)

SETON, E. T. The Arctic Prairies. New York, Charles Scribner's Sons (1911).



these streams are at Selwyn and Theitaga Lakes, respectively, between 50 and 100 miles south of the northern limit of timber. In another report<sup>1</sup> Tyrrell has this interesting observation, "One small isolated grove of White Spruce was found on a high sandy island in Hatchet Lake, standing out conspicuously in the midst of the surrounding forest of small Black Spruce." Hatchet Lake is about 100 miles southeast of the eastern end of Lake Athabaska, and far into the range of the Pine, so that we may look upon this grove as another isolated southern stand of the third type similar to those described above.

There have been striking changes in the land forms of the region in post-Pleistocene time. Topographic evidence indicates that the ice front retreated from southwest to northeast across the country, holding impounded for considerable periods the waters of the Athabaska and Peace Rivers to form a series of post-Glacial lakes which were progressively smaller, lower in elevation, and more recent, to the northeastward.<sup>2</sup> Morainic deposits left by the melting ice included high ridges which must have stood out as islands in the lower lakes. Thus we may establish the soil surfaces of the sandy hill tops west of the Slave River as considerably older than those of their immediate surroundings, and they must have been available for plant cover long before these lower levels. The topographic history of the hill tops noted by Moss in central Alberta has not been studied. With these topographic changes there must have occurred a climate gradually shifting from one similar to that of the present arctic tundra to what we have now. So far as we know there has been no change other than one of amelioration.<sup>3</sup>

The thick spruce woods, then, are on somewhat younger soils of the uplands, and on the still younger silts of the flood plains formed in the last of the lake bottoms. The open spruce woods west of the Slave River are on the oldest hill tops. The Great Slave Lake woods, however, as well as those of Sand Point, though closely related to the ones

<sup>1</sup>TYRRELL, J. B., assisted by Dowling, D. B. Report on the country between Athabaska Lake and Churchill River with notes on two routes traveled between the Churchill and Saskatchewan Rivers. (Canad. Geol. Surv. Ann. Rept. VIII. 12. 1896.)

<sup>2</sup>CAMERON, A. E. Post-Glacial Lakes in the Mackenzie River Basin, Northwest Territories, Canada. (Jour. of Geol. xxx. 337-53. 1922.)

RAUP, H. M. The distribution and affinities of the vegetation of the Athabaska—Great Slave Lake Region. (Rhodora, xxxii. 187-208. 1930.)

<sup>3</sup>TYRRELL, J. B. Changes of climate in north-western Canada since the glacial period. Die Veränderungen des Klimas seit dem Maximum der Letzten Eiszeit. (11th Internat. Geol. Congress, Stockholm (1910), p. 389-91.)

RAUP, H. M. Botanical investigations in the Wood Buffalo Park. In prep.



on the old hills west of the Slave River, are on very recently formed lake shore sand plains and beach ridges. This indicates that the lengths of time since their probable origins will not of itself account for their nature or distribution since they occupy some of the oldest and youngest surfaces

Elevation above the general land surface, with consequent local modification of climatic and edaphic factors may have something to do with the occurrence of this forest on the high ridges west of the Slave River and in central Alberta. But mere elevation appears ineffective since the type also grows very near the level of Lake Athabaska at Sand Point, and on Great Slave Lake. In the latter region the climate in general, as far as it is indicated by the vegetation, is more arctic in character than near the western end of Lake Athabaska, so that we might expect some sort of change in the forests. As noted above, this change is shown by the elimination of the Jack Pine to the north-eastward.

The park-like spruce woods at Sand Point and west of the Slave River, although differing widely in the age and elevation of their soils, have this in common—that they are in places which are exposed to cold storm winds, mostly from the north and east, and that their soils are dry and sandy. It is probable that woods of this type in central Alberta may be described in the same way. Similar soils not so exposed have jack pine or mossy spruce woods, but the question of what any other type of soil would produce in such exposed places needs further study. The only evidence we have in this connection is on isolated granite hills in the Athabaska-Peace delta where small patches of clayey soils of early lacustrine origin have natural prairie on them. Undoubtedly a study of the various habitats in the so-called “Barren Lands” or “Arctic Prairies” would throw some light on the matter.

H. E. Pulling, basing his conclusions upon field investigations of roots in north-central Manitoba, suggests that an important factor determining the northern limits of various trees is the relation between the root habits and the permanently frozen condition of the subarctic soils.<sup>1</sup> He classes the Black Spruce, Tamarac, and White Birch as having a rigid shallow root habit, White Spruce as having a flexible shallow root habit, Black Poplar a deep flexible habit, and Jack Pine a deep rigid one. Northward, of course, soils are increasingly shallow due to the frozen subsoil. In general the distribution of trees in the

<sup>1</sup>PULLING, H. E. Root habit and plant distribution in the Far North. (Plant World, XXI. 223-33. 1918.)



central part of the Mackenzie basin may be correlated with these findings. White Spruce, with a shallow flexible root habit, is most successful in coping with subarctic conditions, and extends far out on the Barren Lands in favored places. Other shallow rooted species, but having a rather inflexible system—Birch, Tamarac, and Black Spruce—have a wide range in the Mackenzie basin but are nowhere so tolerant, with the possible exception of the Birch, as the White Spruce. Black Poplar and Jack Pine, with deep root systems, have somewhat similar ranges. The former, like the Pine, has its northeastern limit near the eastern end of Great Slave Lake. Another species, White Pine, also listed by Pulling as having a deep rigid root habit is entirely absent from the region so far as is known.

On the other hand, if this relationship is everywhere of first importance, we should expect to find, for instance, that the sandy soils on Sand Point, on the high moraines west of the Slave River, and on some of the hills in central Alberta, differ from those very near them in being frozen nearer the surface. Although no investigations have been made in these places, it does not seem probable that they would show the sharp differences. Great variations in elevation such as occur between the Slave River and the Caribou Mountains are known to be accompanied by frost differences in the soils, but these are not to be expected, for example, on a low sandy lake shore like Sand Point. Soil frost, therefore, although it is probably of first importance in the general distribution of the species in question, may not account for all the facts relating to the occurrence of the isolated stands of open Spruce; and we must conclude that exposure to storm winds may be a prime factor.

The southern occurrences of northern park-like Spruce may be looked upon as remnants of an earlier forest which occupied the sandy soils throughout the region when a slightly more arctic climate, similar to that now prevailing about the eastern part of Great Slave Lake, was general farther south. There are vast areas of sandy uplands, now covered with jack pine timber, whose soils show no evidence of the humus accumulations which would have arisen from an earlier, heavier timber with a moss mat. These areas must have had an open spruce timber with a thin lichen mat during a somewhat more arctic climate, since the Jack Pine, as indicated by its present range, would then have had its northern limit farther south. These facts suggest that the Jack Pine is the most recent arrival among forest trees in this part of the Mackenzie basin, and that it has replaced the Spruce except in situations excessively exposed.



The mossy spruce woods on the uplands west of the Slave River appear to be developing from jack pine stands by stages which are readily seen. Young groves of the latter are of close-growing, rather spindling trees, but later they thin out and produce much larger crowns with arching branches. During this stage young and vigorous Spruces come up in the shade of the Pines, accompanied by the beginnings of the moss mat. Later stages show a predominating spruce stand in which there are very old, scattered, and dying Pines festooned with lichens, and with small bunches of green needles at the tips of their long branches.

How the Pines invaded the country in the first place, crowding out a park-like spruce forest as suggested above, is uncertain. Study of the country between Athabaska and Great Slave Lakes would undoubtedly reveal a series of intermediate stages which would indicate the transition. It is probable that Pines would invade the open spruce forest in small numbers at first, not enough to make much shade, but sufficient to crowd out the older Spruces and prevent the growth of younger ones. As the climate ameliorated we may suppose that the Pines became more abundant, with such changes in soil and general conditions that Spruces could again invade and form the mossy woods so common now on the more southern uplands. Among the areas thus far studied by the writer those of Lake Athabaska come nearest to illustrating these intermediate stages. As one passes along Sand Point toward the base, the change from open spruce to very open jack pine woods in which many of the trees are old is a gradual one. Still farther inland the Pines are in a closer stand.

The Lake Athabaska pine woods, being farther to the northeastward, nearer the limit of range, and occurring on or near the windswept margins of the lake, are growing under more difficult conditions than those west of the Slave River, and could therefore be considered, as a whole, nearer to an original condition. This is borne out by the above-mentioned gradual transition from old spruce to old pine woods on Sand Point, and by the fact that so far no place has been found where the sand plain pine woods are developing into mossy spruce woods as they are on the uplands. Whether this is due to youth or exposure, or both, is uncertain. They are surely growing upon much younger land surfaces. Furthermore, being near the northeastern limit of its range, the Pine is undoubtedly more selective in its choice of habitats than farther south, and more circumscribed in its ability to invade other associations.



Burning probably aids the spread of pine woods by opening other timber associations, but the normal course of development on the uplands to spruce woods seems to be only retarded by this means. Whether the same agency furthered the replacement of park-like spruce woods by the Pine is uncertain. If it were a very important factor we should expect that the sandy hill top Spruce of the uplands would long ago have been removed. But since it has not we must look for other causes for the present relationships.

#### SUMMARY

In the distribution of the existing pine and spruce forests of the central part of the Mackenzie basin there is evidence that the earliest post-Glacial timber was one of White Spruce arranged in an open association on sandy soils. The ground cover in this timber was probably a thin mat of lichens and heaths; and the whole persists to the present time as a well-developed type near the arctic timber line. With the amelioration of the climate after the recession of the glacier, other less tolerant species could migrate into the country, among them the Jack Pine. The Pine could successfully compete with the Spruce on the wide-spread sterile sandy soils, and soon formed an open association resembling in aspect that of the Spruce. It is probably typified now by the sand plain pine woods of the Athabaska Lake district.

An increasing growing season, more available moisture, and more rapid decay then permitted the accumulation of organic materials in the soils at a faster rate than had been possible before. This inaugurated a forest succession on the higher and relatively older land surfaces southwest of Great Slave Lake. The richest woods growing in the region now are of White Spruce with a moss mat and light undergrowth; and they appear to develop directly from mature jack pine woods, although in many places burning and the invasion of Trembling Aspen and Black Poplar have prolonged the process. As noted elsewhere by the writer,<sup>1</sup> there is floristic as well as topographic evidence of the relative immaturity of even these richer spruce forests. Many species of wide range across the continent in the coniferous forests are absent or very rare in the Athabaska-Great Slave Lake region, and suggest that the latter have not had sufficient time under the existing subarctic conditions to develop further.

The most recently formed spruce woods are on local flood plain

<sup>1</sup>RAUP, H. M. See p. 339, foot-note 2.



deposits along the present streams. They resemble the upland mossy Spruce but have a thinner ground cover and relatively heavier undergrowth.

In a few local areas far to the south and southwest of the present park-like spruce forest there are woods which appear to be relics of the former wide distribution of this type. They are on both old and very young land surfaces, at both high and low elevations, but are all in places unusually exposed to storm winds. It is supposed that the Jack Pine has not been able to invade the original Spruce in these exposed situations.

#### EXPLANATION OF THE PLATES

- Plate 72. LEFT: Lowland spruce forest along Peace River near Peace Point. Note ground cover of *Equisetum pratense*.  
RIGHT: Upland spruce woods about 40 miles west of the upper Slave River, near Pine Lake.<sup>1</sup>
- Plate 73. UPPER: Open spruce woods on sand plain at the eastern end of Great Slave Lake (Ft. Reliance).  
LOWER: Open woods of *Pinus Banksiana*, *Picea mariana*, and *Betula neoalaskana* near Shelter Point, Lake Athabaska.

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<sup>1</sup>The writer is indebted to the National Museum of Canada for use of the two photographs in this plate.